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TURKEY LAKES WATER STUDY:

HYDROGEOLOGICAL INSTRUMENTATION AND AQUIFER MATERIALS

(Updated 1986)

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MANAGEMENT PERSPECTIVE

This report provides background information concerning all Ground Water Division installations in the Turkey Lakes Watershed. It is intended to serve as a source of basic data for other scientists working in the area and provides a permanent record for the sites studied during the LRTAP program. In addition, the results of the sediment analyses performed on selected samples recovered during the drilling program are presented for the use of other researchers.

PERSPECTIVE DE GESTION

Ce rapport fournit des renseignements de base sur toutes les installations de la Division des eaux souterraines dans le bassin hydrographique des lacs Turkey. Il se veut une source de données fondamentales à l'usage d'autres scientifiques travaillant dans le domaine et constitue un registre permanent à l'égard des emplacements étudiés dans le cadre du programme de transport à distance des polluants atmosphériques (TADPA). En outre, les résultats des analyses de sédiments effectuées sur des échantillons choisis prélevés au cours du programme de forage sont présentés à l'intention d'autres chercheurs.

ABSTRACT

Fifty-seven wells (69 sampling points) ranging in depth from 0.5 to 9.7m are currently in use in the Turkey lakes Watershed ground water study. During the drilling program 50 overburden samples were collected, freeze-dried and sieved into seven fractions. Each fraction was subjected to an acid-base titration to measure its relative acid neutralization capacity (ANC). The ANC expressed as $\%CaCO_3$ by weight, increases with depth from 0.3% at one metre to 1.4% at seven metres. The average ANC value for each of the five main basins ranges from 0.6 to 1.3% by weight. X-ray diffraction analysis of the silt-clay fraction of selected samples showed quantities of montmorillonite and illite. Forty fractions, from eleven sites, contained inorganic carbon ranging from trace levels to 0.26% by weight. Organic carbon concentrations in the same fractions ranged from not detectable to 0.82% Sulphur concentrations were below the detection limit of 0.02%.

RÉSUMÉ

Cinquante-sept puits (69 points d'échantillonnage) allant d'une profondeur de 0,5 à 9,7 m sont actuellement utilisés dans le cadre de l'étude sur les eaux souterraines du bassin hydrographique des lacs Turkey. Pendant le programme de forage, 50 échantillons de couverture ont été prélevés, lyophilisés et tamisés en sept fractions. Chaque fraction a été soumise à un titrage acide-base pour mesurer sa capacité relative de neutralisation des acides (CNA). Cette dernière, exprimée en $\%CaCO_3$ par poids, augmente avec la profondeur, soit de 0,3 % à un mètre à 1,4 % à sept mètres. La valeur moyenne de la CNA pour chacun des cinq bassins principaux varie de 0,6 à 1,3 % par poids. L'analyse par diffraction X de la fraction limon-argile d'échantillons choisis a révélé des quantités de montmorillonite et d'illite. Quarante fractions provenant de onze emplacements avaient une teneur en carbone inorganique allant de l'état de trace à 0,26 % par poids. Les concentrations de carbone organique dans les mêmes fractions allaient de non détectables à 0,82 %. Les concentrations de soufre se situaient en-dessous de la limite de détection de 0,02 %.

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INTRODUCTION

Environmental studies were initiated in the Turkey lakes watershed during 1980 in order to determine the effect of long range transport of atmospheric pollutants (LRTAP) on a relatively sensitive system under moderate to high sulphate loadings. In order to determine the mechanisms controlling the acidification process it is necessary to investigate the interactions of atmospherically deposited strong mineral acids with forest, soil, sediments, surface and ground water systems and associated biotic communities (Jeffries and Semkin, 1982).

The present report provides a summary of the analyses of the overburden samples collected and of the physical description of ground water monitoring installations completed in the Turkey Lakes Watershed in the period 1980 - 1985. Results of the analysis of the water samples collected from these installations will be presented in subsequent papers. The information gathered from these sites is necessary to understand the processes occuring within the ground water system and also the interactions between the surface water and ground water systems. Grain size and relative acid neutralization capacity (ANC) analyses are presented for the overburden materials recovered during piezometer installation. Results of carbon, sulphur, and X-ray diffraction analyses are given for selected samples.

STUDY AREA DESCRIPTION

The Turkey Lakes Watershed is located approximately 50 km north of Sault Ste. Marie, Ontario and 25 km east of Lake Superior (Figure 1) in Norburg and Wishart Townships. The watershed is approximately 3.5 km by 3.0 km (10.5 sq. km) and contains a chain of 5 lakes (maximum 497 m AMSL, minimum 372 m AMSL). Topographic relief is marked in the basin, with a maximum elevation of 628 m AMSL (Batchawana Mt.) and a minimum elevation of 340 m, measured at the lowest streamflow station on the discharge stream. The total relief is almost 300 metres and local variations within the study area result in a series of small, generally sharply defined surface water sub-basins (Jeffries and Semkin, 1982).

The study area is located on the Canadian Shield in which the bedrock is composed of alumino-silicates of Precambrian age. Bedrock geology has been discussed by Jeffries and Semkin (1982) and only a brief summary will be given here (Figure 2).

The watershed is underlain by basic to intermediate metavolcanics (greenstone) described as very fine-grained, massive to slightly schistose, grey green to dark green or black, and having a composition ranging from andesite to basalt (Giblin, 1966: Armburst, 1966). This has been successively intruded by Archean (biotite and hornblende) granite and numerous, small Lower Keweenawan diabase dikes (Giblin, 1966: Armburst, 1966). These dikes, which are discontinuous, are harder than the rock which they cut, and therefore, stand out as hills or ridges (Armburst, 1966).

Minor amounts of calcite are commonly found in the metavolcanic rocks in the Turkey Lakes study area. At the Tribag Mine site, approximately 7.5 km WNW of the study area, calcite has been reported associated with the sulfide ores (Nichol, 1977, Armburst, 1967, Blecha, 1965). This calcite appears to be associated with the intrusion of the surrounding granite during the Archean period. The presence of even minor amounts of calcite in the surrounding bedrock could be very important if it was transported into the basin till during glaciation.

Basin hydrology is partly controlled by major faults and this is reflected by the path of the discharge stream from Big Turkey Lake and other smaller streams in the watershed (Figure 2, Jeffries and Semkin, 1982).

SURFICIAL GEOLOGY

Mapping of the surficial geology in the study area has been carried out by air photograph interpretation, supported by site specific ground verification (Tucker, 1980) and is discussed by Jeffries and Semkin (1982), and shown in Figure 3.

Most of the watershed is covered by a ground moraine. The silt-sand till is buff-light brown in color and contains numerous clasts in some locations. Ice contact silt, sand and gravel deposits are found in the discharge valley downstream from Big Turkey Lake. Small organic deposits occur throughout the basin, generally adjacent to lakes and streams.

Cowell and Wickware (1983) described the soil chemistry and morphology of 12 upland sites, in the discharge stream area of the watershed, as follows: "The texture of the uppermost portion of the profile is loam to silt loam. Coarser textures such as sandy loams and sands generally occur at depth, especially 45 cm. This textural contrast is attributed to the presence of 2 tills throughout much of the watershed. In lower to moderate elevations a fine-textured ablation till overlies a coarser, more compact basal till. Both tills have significant gravel and stone fractions." Also from this study, the soil pH, in $CaCl_2$, ranges from 4.0 at the surface to pH 5.1 in the BC and C horizons and the soils are classified as very acidic. The inorganic carbon ranges from 0.11 to 1.94% as determined by using a Leco Carbon Analyzer. These values are mainly for the A and B horizons as in most areas, the C horizon occurs at depths > 80 cm (the depth of the profile studied).

Kusmirski and Cowell (1983) examined the mineralogy of 18 samples representing the relatively unweathered horizons. The unconsolidated sediments are more representative of acid type rocks, such as granite, than of meta-volcanics. They reflect bedrock lithologies to the north and northeast of the area, in the direction from which glacial ice advanced, rather than the metavolcanic bedrock in the study area. Thus, the surficial tills have less carbonate than the underlying bedrock but this may not represent a lower capacity to provide buffering against the effects of acidic precipitation.

Geophysical surveys were carried out during June 1980, May and June 1981 and June 1982 to determine the thickness of the till (Elliot, 1985). The overburden thickness is generally less than two metres and in upland areas and in the Batchawana Lake sub-basin the thickness approaches zero with bedrock frequently exposed. There are, however, areas associated with bedrock depressions, valleys, and/or fault zones where the thickness of the overburden reaches 70 m, as indicated by electrical resistivity measurements (Elliot, 1985).

WELL INSTALLATIONS

Drilling programs were carried out in the watershed during summer 1981, March 1982 and October-November 1982 using hydraulic percussion methods. During December and January 1984-85, a rotary auger method was used but was less successful due to the stony nature of the tills. In total, 69 sampling tips have been installed in 57 separate wells located in eight sub-basins of the watershed (Figure 4). These wells range in depth from 0.5 m to 9.7 m (Table 1) and are located in a variety of terrains, ranging from upland hillside (recharge areas) to lake margins (discharge zones). The piezometers vary in diameter from 0.64 to 5.08 cm (ID). All piezometer tips are wrapped with nitex cloth.

The wells were developed immediately following installation using a peristaltic pump. The wells are currently sampled for 24 parameters. Sampling is carried out as follows:

a) the static level is measured,
b) field measurements for pH, Eh, specific conductance, temperature and dissolved oxygen are made where possible,
c) samples are collected using a peristaltic pump following the method described by Johnston and Flavelle (1987) and analyzed in the laboratory for major ions (Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, SO_4^{2-}, Cl^{-}, NO_3^{-}, NO_2, NH_4, SiO_2, total alkalinity, metals (Fe, Al, Mn, Zn, Cu, Ni, Cd and Pb), pH, and specific conductance.

The frequency of sampling depends on the location (ease of access) and the recovery rate of each piezometer following pumping. The wells which are sampled monthly encompass the entire range of ground water chemistries which occur in the watershed.

Ground water seepage meters, constructed from plastic drums were installed in Big Turkey and Lower Batchawana Lake. Installation of the seepage meters was hampered by the occurrence of large volumes of deteritus (sticks, logs, etc.) and boulder pavement which are common in the near shore areas. Measurements to determine the volume of ground water discharge through the lake bottom were made but the meters were abandoned due to problems in obtaining reliable samples.

SOIL SAMPLING

A total of 50 sediment samples were collected during field drilling programs in March 1982 (19 samples) and October - November 1982 (31 samples). In most cases, the sample was obtained from the overburden in the zone adjacent to the installed piezometer tip. The sample designation is the same as that for the associated well (Figure 4).

All samples were freeze dried and gently disaggregated using a rubber mallet. The grain size distribution was determined by dry sieving using standard Tyler sieves. The percentage of the gravel, sand and silt-clay fractions for each sample are given in Table 2. The samples are predominantly sand and gravel in composition. No significant correlations exist between grain size and depth in the soil profile or location within the watershed.

An attempt was made to measure the carbonate content of each size fraction using an acid-base titration. A weighed sediment sample was treated with a known volume of 1.0N HCl, allowed to react for 4 hours then the excess HCl titrated to an end point of pH 8 using 0.5N NaOH (Carver, 1971). This method measures the presence of proton acceptors, which are generally assumed to equal the inorganic carbon content. Subsequent determination of the inorganic carbon using a combustion method (Leco furnace) brought this assumption into question. The results of the acid-base titration are reported as the relative acid neutralization capacity (ANC) of the soil. This capacity includes carbonates, aluminum oxy-hydroxides and any soil precipitates capable of neutralizing the added acid. Relative ANC values (reported as $\%CaCO_3$ by weight) and grain size histograms for all samples are given in Figure 5. In most cases the distribution of the relative ANC values closely parallels the size fraction distribution.

A summary of the average relative acid neutralizing capacity of the overburden both by separate sub-basins and by depth for all basins is given in Table 3. In areas with till deposits (Batchawana Lake, Wishart Lake, Big Turkey Lake), the upper part of the watershed has the lowest mean value (0.58%). The ANC values increase from 0.17% at less than 1 metres to 1.4% at depths greater than 4 metres. The increase in the standard deviation relative to mean at greater than 4 metres depth is due to a few rather high values (up to 5.73%) found at depth.

The X-ray diffraction analyses of the 0.075 mm fraction for selected samples are presented on Table 4. The major clay minerals are chlorite, which is present in all the samples, and illite which is found in one sample and in trace quantities in three other samples. Quartz, feldspar and amphibole are present in all samples. A detailed analysis of sample number H1-1.8l (Flavelle, pers comm) revealed the presence of quartz, (Na-Ca)- feldspar, K-feldspar, amphibole, biotite, kaolinite, vermiculite and possibly chlorite (in order of decreasing concentration).

Selected samples were analyzed for inorganic carbon, organic carbon and sulphur (Table 5). Of the 40 fractions analyzed, only two contained sulphur at concentrations > 0.02% by weight, suggesting that autogenic sulphur is not a significant contributor to the acid-base reactions occuring in the overburden. Inorganic carbon constitutes 0.08% of the overburden except in the shallow area (HU-0.68 m) near Lower Batchawana Lake. At this site all fractions analyzed contain between 0.12 and 0.2% inorganic carbon. The organic carbon content is also 0.08% except for HU-0.68 and the > 0.075 mm fractions of samples HU1-1.8 and WO-7.0. The range of values for these samples is 0.16 to 0.82%.

SUMMARY

The field installations necessary for the watershed wide study were completed in January, 1985. Sixty-nine sampling points ranging in depth from 0.5 to 9.7 m were evaluated and a long term sampling schedule established. Sampling for chemical and hydrogeological characteristics continued through the 1986 and 1987 field seasons.

Fifty overburden samples were collected during drilling, then freeze-dried and sieved. All size fractions were analyzed for their relative acid neutralization capacity. For selected samples, x-ray analysis showed the presence of quartz, feldspar, amphibole, chlorite, montmorillonite and illite. Inorganic carbon ranged from not detectable to 0.26% while organic carbon had a maxmum of 0.02% Sulphur concentrations were below the detection limit of 0.02% except in two cases.

Further analyses will be conducted to determine more detailed physical and chemical properties of the soils within the basin. This detailed knowledge is required to determine the mechanisms controlling the acidification process in the ground water/aquifer system.

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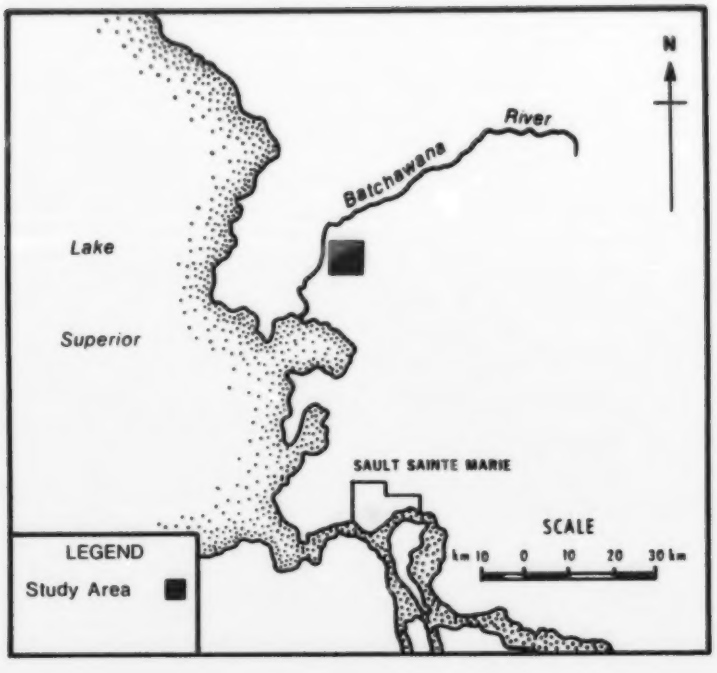
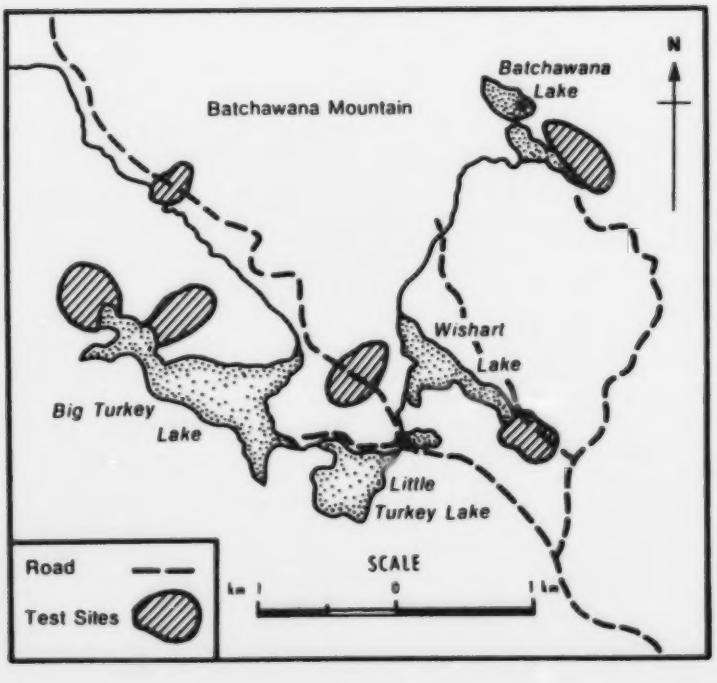
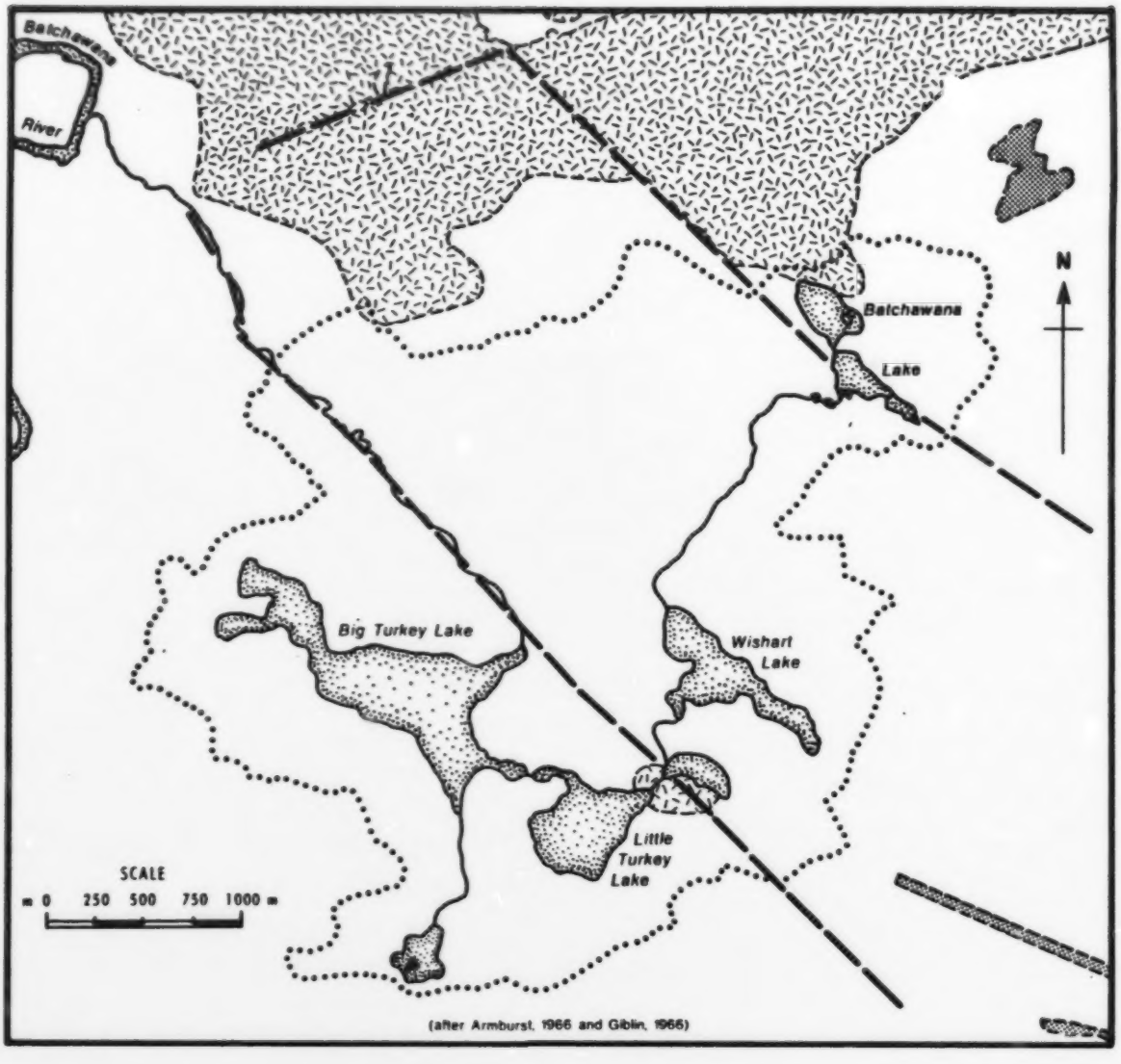

N
River
Batchawana
Lake
Superior
SAULT SAINTE MARIE
SCALE
km 10 0 10 20 30 km
LEGEND
Study Area


N
Batchawana Mountain
Batchawana
Lake
Wishart
Lake
Big Turkey
Lake
Little
Turkey Lake
SCALE
km 1 0 1 km
Road
Test Sites



LEGEND

PRECAMBRIAN PROTEROZOIC

Keweenawan Diabase

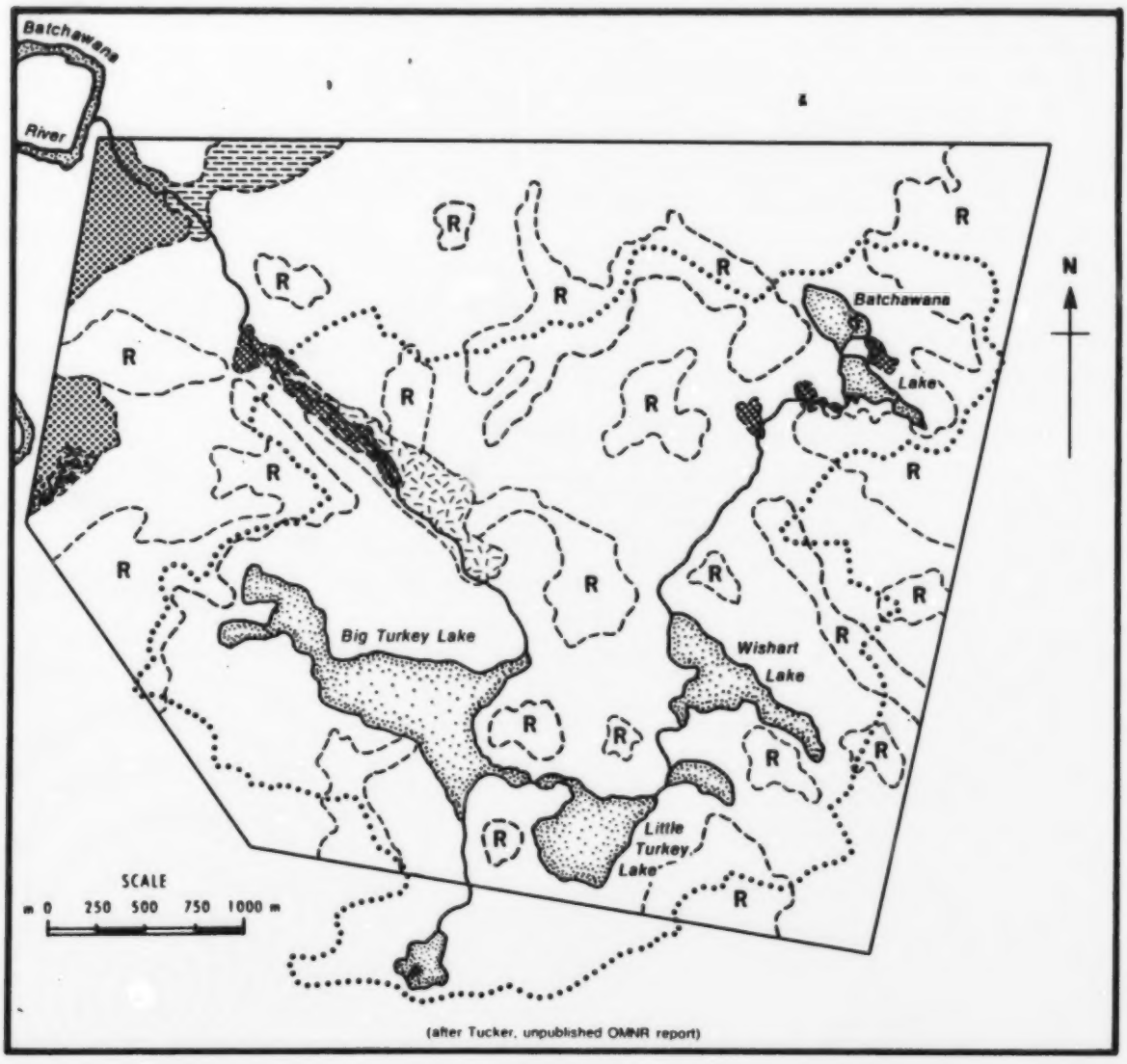
ARCHEAN

Biotite (Hornblende) Granite

Basic to Intermediate Metavolcanics

Fault

Watershed Boundary



LEGEND

Organic Cover. Thin But Continuous

Alluvium, Variable Texture; Silt to Peble, Gravel

Glaciolacustrine Deltaic Deposits. Stratified Silt, Sand and Gravel

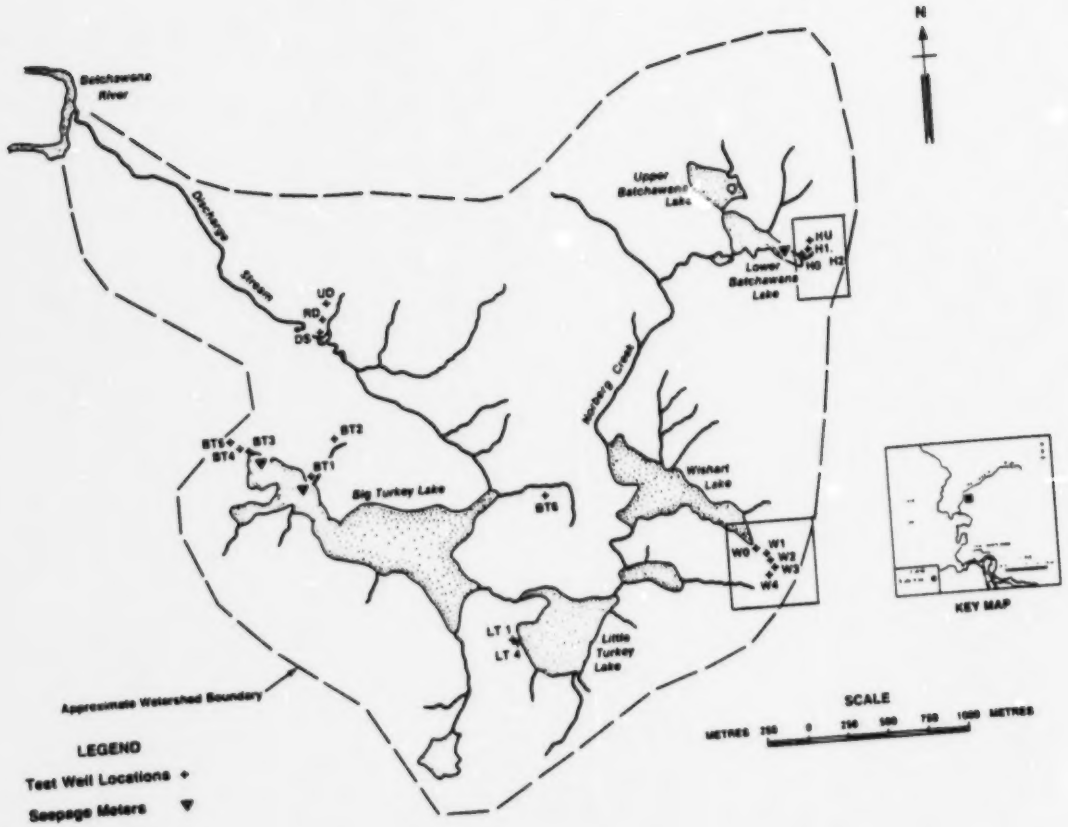
Glaciofluvial Deposits. Discontinuous Silt, Sand and Gravel Overlying Bedrock

Ice-Contact Silt, Sand and Gravel Intermixed With Englacial, Sandy Till

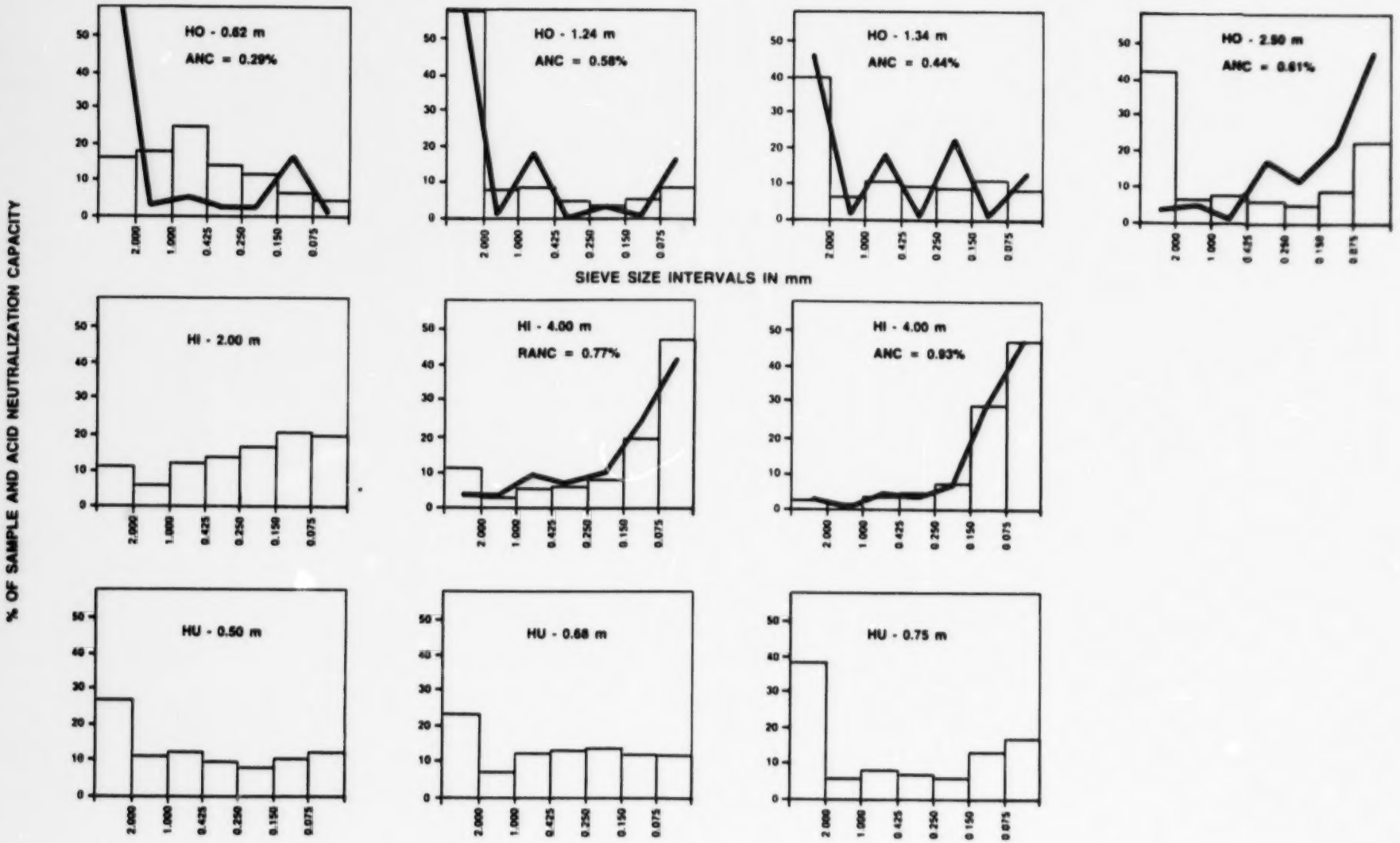
Till. Silty Sand, Buff-Brown. Variable in Thickness But Generally Close to Bedrock

Rock With Very Thin, Discontinuous Colluvium and Till — R

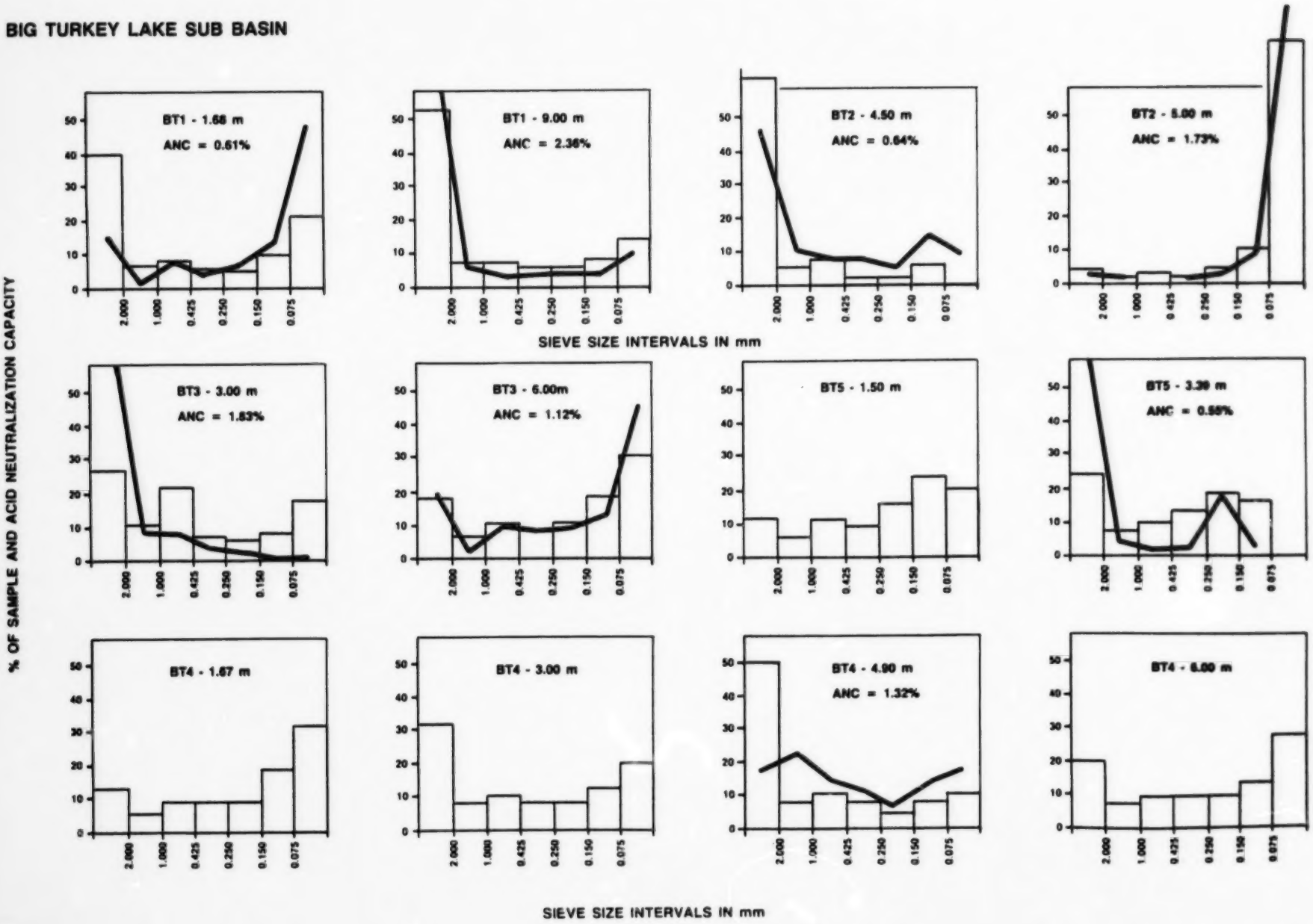
Watershed Boundary

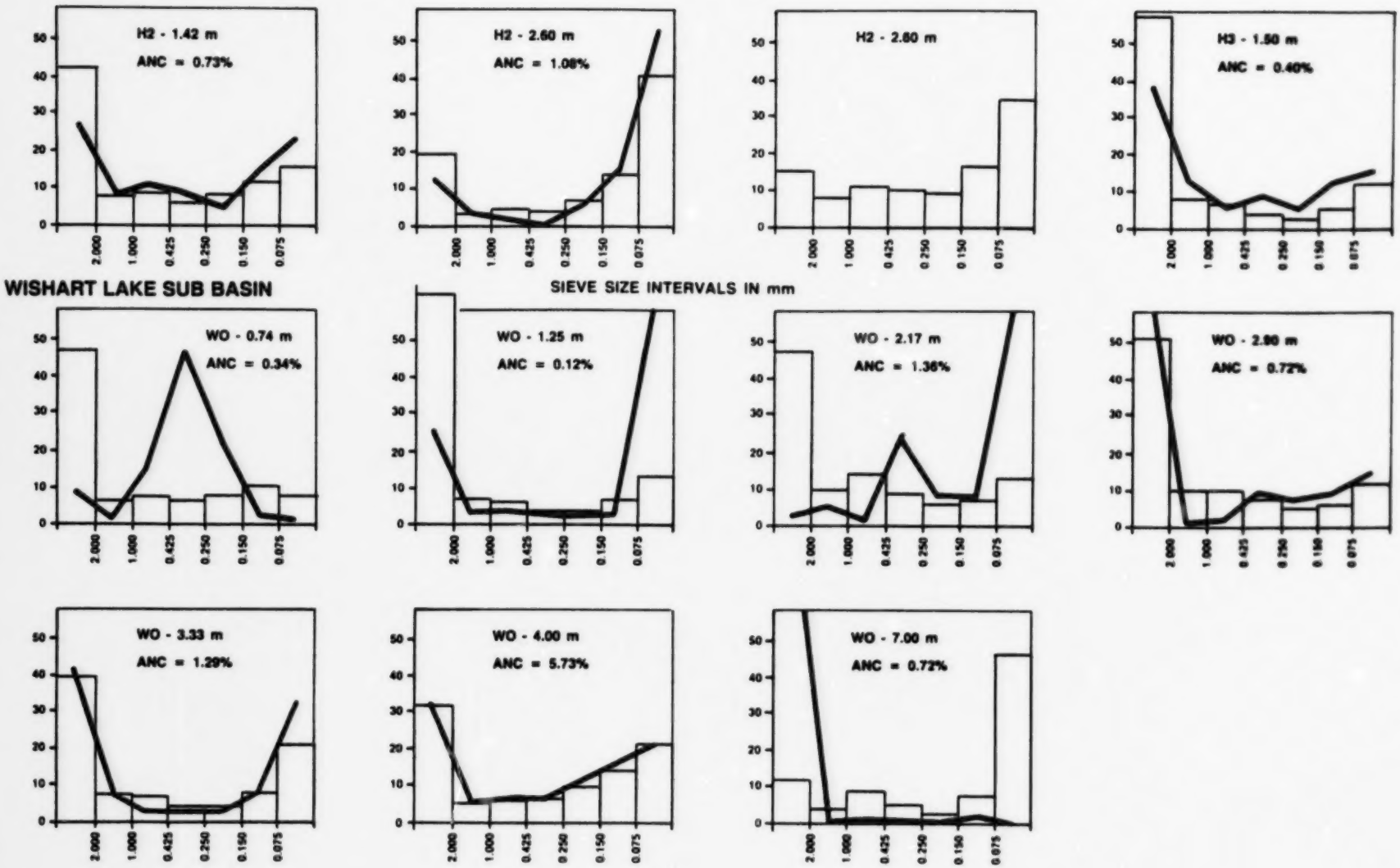

Batchawana River
Discharge Stream
Upper Batchewana Lake
Lower Batchewana Lake
HU
H1
H0
H2
UD
RD
DS
Marsberg Creek
BT5
BT4
BT3
BT2
BT1
Big Turkey Lake
BT6
Wishart Lake
W0
W1
W2
W3
W4
LT 1
LT 4
Little Turkey Lake
N
KEY MAP
Approximate Watershed Boundary
LEGEND
Test Well Locations +
Seepage Meters ▼
SCALE
METRES 250 0 250 500 750 1000 METRES

BATCHAWANA LAKE



BIG TURKEY LAKE SUB BASIN




% OF SAMPLE AND ACID NEUTRALIZATION CAPACITY
WISHART LAKE SUB BASIN
H2 - 1.42 m
ANC = 0.73%
H2 - 2.60 m
ANC = 1.08%
H2 - 2.80 m
H3 - 1.50 m
ANC = 0.40%
SIEVE SIZE INTERVALS IN mm
WO - 0.74 m
ANC = 0.34%
WO - 1.25 m
ANC = 0.12%
WO - 2.17 m
ANC = 1.36%
WO - 2.90 m
ANC = 0.72%
WO - 3.33 m
ANC = 1.29%
WO - 4.00 m
ANC = 5.73%
WO - 7.00 m
ANC = 0.72%
SIEVE SIZE INTERVALS IN mm

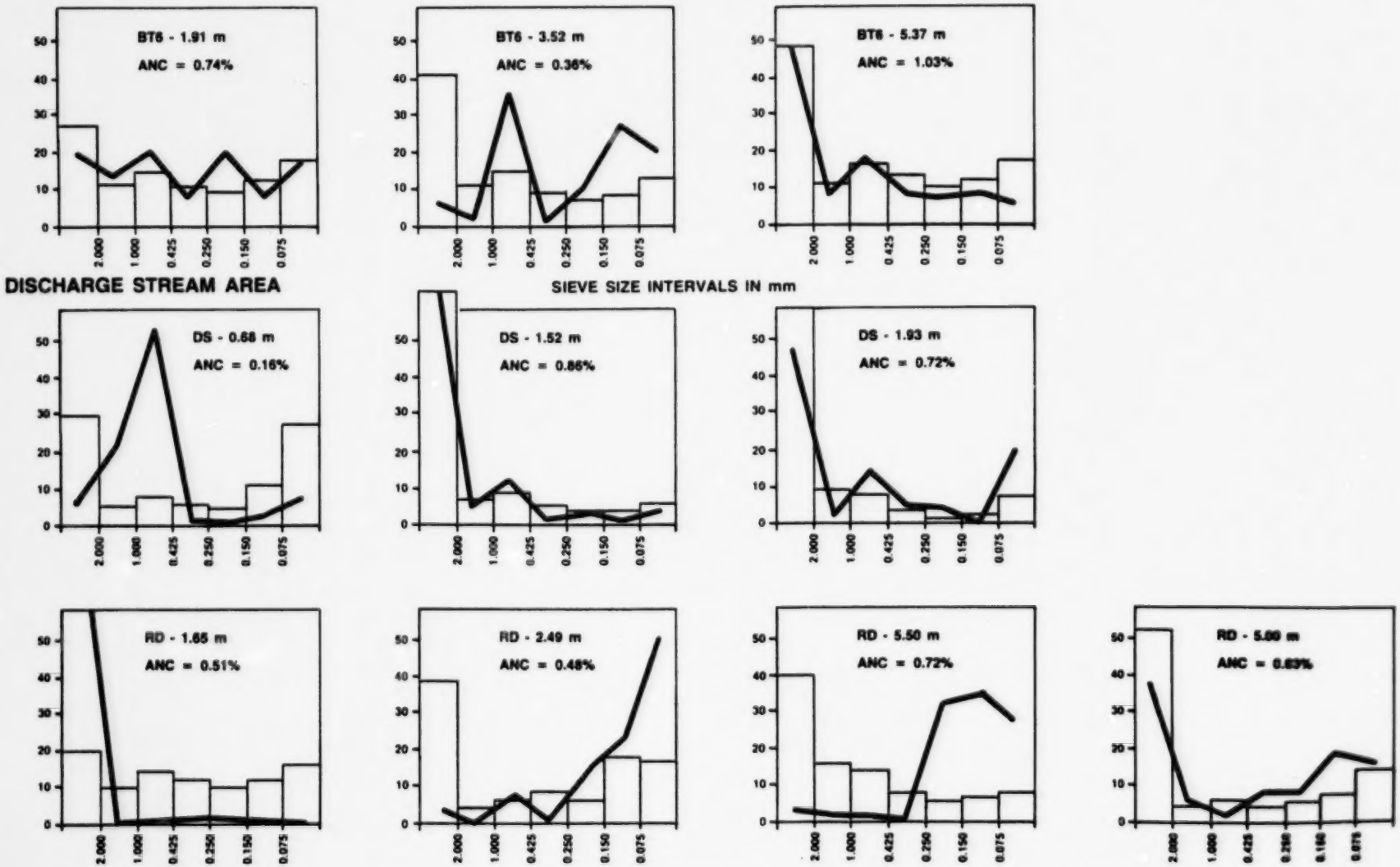

% OF SAMPLE AND ACID NEUTRALIZATION CAPACITY
DISCHARGE STREAM AREA
BT6 - 1.91 m
ANC = 0.74%
BT6 - 3.52 m
ANC = 0.36%
BT6 - 5.37 m
ANC = 1.03%
SIEVE SIZE INTERVALS IN mm
DS - 0.68 m
ANC = 0.16%
DS - 1.52 m
ANC = 0.86%
DS - 1.93 m
ANC = 0.72%
RD - 1.65 m
ANC = 0.51%
RD - 2.49 m
ANC = 0.48%
RD - 5.50 m
ANC = 0.72%
RD - 5.09 m
ANC = 0.63%
SIEVE SIZE INTERVALS IN mm

TABLE 1: PHYSICAL DESCRIPTION OF TEST WELLS IN THE TURKEY LAKES WATERSHED

FIELD IDENTIFIED	NAQUADAT NUMBER	DEPTH IN[1] METERS	SCREEN LENGTH(cm)	SCREEN DIA(cm)	ELEVATION[2] IN METERS	HORIZONTAL[3] DIST. TO LAKE (m)
LOWER BATCHAWANA LAKE SUB-BASIN						
HO - 0.62	1001	0.62	30.5	1.27	0.40	N.S.
HO - 1.24	1002	1.24	61	"	0.36	"
HO - 1.23	1003	1.34	"	"	0.39	
H1 - 1.81	1004	1.81	30.5	1.27	3.42	44.2
H1 - 2.78	1005	2.78	"	"	3.31	"
H1 - 3.70	1006	3.70	"	"	3.47	"
HU - 0.5	1007	0.5	30.5	1.27	8.80	N.S.
HU - 0.68	1008	0.68	"	"	8.72	"
HU - 0.75	1009	0.75	"	"	8.78	"
H2 - 1.42	1010	1.42	30.5	1.27	0.98	41.2
H2 - 1.68	1011	1.68	"	"	0.99	"
H2 - 1.82	1012	1.82	"	"	0.99	"
H3 - 1.27	1013	1.27	30.5	1.27	N.S.	N.S.
WISHART LAKE SUB-BASIN						
WO - 0.74	1201	0.74	30.5	1.27	N.S.	N.S.
WO - 1.25	1202	1.25	61.0	"	"	"
WO - 2.17	1203	2.17	"	"	"	"
WO - 2.90	1204	2.90	"	"	"	"
WO - 3.33	1205	3,33	"	"	"	"
W1-Stand pipe	1206	5.34	54	5.08	5.66	93.3
W1 - 1	1207	0.75	21.6	0.64	"	"
W1 - 2	1208	1.75	"	"	"	"
W1 - 3	2309	2.75	"	"	"	"
W1 - 4	2310	3.75	"	"	"	"
W2-Stand pipe	1211	9.74	54	5.08	5.45	98.1
W2 - 2	2313	3.2	21.6	0.64	"	"
W2 - 3	1214	4.7	"	"	"	"
W2 - 4	1215	6.2	"	"	"	"
W2 - 5	1216	7.7	"	"	"	"

TABLE 1: (cont'd)

FIELD IDENTIFIED	NAQUADAT NUMBER	DEPTH IN[1] METERS	SCREEN LENGTH(cm)	SCREEN DIA(cm)	ELEVATION[2] IN METERS	HORIZONTAL[3] DIST. TO LAKE (m)
WISHART LAKE SUB-BASIN (cont'd)						
W3-Stand pipe	1217	3.74	54	5.08	6.54	171.9
W3 - 1	1218	1.2	21.6	0.64	"	"
W3 - 2	1219	2.2	"	"	"	"
W3 - B	1220	4.57	"	1.27	6.47	175.6
W4-Stand pipe	1221	6.89	54	5.08	6.54	179.8
W4 - 1	1222	1.35	21.6	0.64	"	"
W4 - 2	1223	2.35	"	"	"	"
W4 - 3	1224	3.35	"	"	"	"
W4 - 4	1225	4.35	"	"	"	"
W4 - B	1226	3.64	"	1.27	6.52	186.5
W4 - C	1227	3.54	"	"	"	"
BIG TURKEY LAKE SUB-BASIN						
BT1 - 3.41	1401	3.41	61	1.27	0.0	0.0
BT2 - 3.37	1402	3.37	61	1.27	5.13	310
BT2 - 3.95	1403	3.95	"	"	5.21	"
BT3 - 2.34	1404	2.34	61	1.27	0.68	1.85
BT3 - 3.24	1405	3.24	"	"	0.52	2.13
BT4 - 1.67	1406	1.67	30.5	1.27	2.28	101
BT4 - 2.25	1407	2.25	61	"	"	"
BT4 - 3.35	1408	3.35	"	"	"	"
BT4 - 4.91	1409	4.91	"	"	"	"
BT5 - 0.92	1410	0.92	30.5	1.27	10.38	169.7
BT5 - 3.39	1411	3.39	"	"	"	"
BT6 - 1.91	1412	1.91	61	1.27	N.S.	N.S.
BT6 - 3.52	1413	3.52	"	"	"	"
BT6 - 5.37	1414	5.37	"	"	"	"

ABLE 1: (cont'd)

FIELD DENTIFIED	NAQUADAT NUMBER	DEPTH IN[1] METERS	SCREEN LENGTH(cm)	SCREEN DIA(cm)	ELEVATION[2] IN METERS	HORIZONTAL[3] DIST. TO LAKE (m)
ITTLE TURKEY LAKE SUB-BASIN						
T - 0.84		0.84				
T - 1.47		1.42				
T - 2.21		2.21				
T - 2.39		2.39				
ISCHARGE STREAM SUB-BASIN						
S - 0.68	1501	0.68	30.5	1.27	N.S.	N.S.
S - 1.52	1502	1.52	61	"	"	"
S - 1.93	1503	1.93	"	"	"	"
S - 1.95	1504	1.95	"	"	"	"
D - 1.65	1505	1.65	61	1.27	N.S.	N.S.
D - 2.49	1506	2.49	"	"	"	"
D - 3.52	1507	3.52	"	"	"	"
D - 3.69	1508	3.69	"	"	"	"
D - 1.52	1504	1.52	30.5	1.27	N.S.	N.S.
D - 2.45	1510	2.45	61	"	"	"

Depth below ground level.
Ground level elevation relative to nearest down gradient lake.
Horizontal distance to nearest down gradient Lake, most likely discharge pt.
N.S. - Not surveyed to date.

TABLE 2: GRAIN SIZE DISTRIBUTION BY PERCENT

SAMPLE NO.	GRAVEL (>2.0mm)	SAND	SILT & CLAY[2] (<0.075mm)
LOWER BATCHAWANA LAKE SUB-BASIN			
H0 - 0.62	17.4	77.3	5.3
H0 - 1.24	58.0	33.2	8.8
H0 - 1.34	41.1	49.2	9.7
H0 - 2.50	41.6	35.1	23.3
H1 - 2.0	11.3	68.6	20.1
H1 - 4.0	10.3	42.3	47.4
H1 - 4.0	2.7	49.3	48.0
HU - 0.5	29.8	56.6	13.6
HU - 0.68	23.6	62.8	13.6
HU - 0.68	26.2	43.9	29.9
HU - 0.75	39.2	43.6	17.2
H2 - 2.6	20.2	37.5	42.3
H2 - 2.6	15.3	50.8	33.9
H2 - 4.0	42.4	40.6	17.0
H3 - 1.5	58.3	29.6	12.1
WISHART LAKE SUB-BASIN			
W0 - 0.74	48.9	42.9	8.2
W0 - 1.25	62.2	24.4	13.4
W0 - 1.75	52.1	33.7	14.2
W0 - 2.17	47.0	41.3	11.7
W0 - 2.90	51.7	36.3	12.0
W0 - 3.33	40.8	37.0	22.2
W0 - 4.0	33.0	45.0	22.0
W0 - 7.0	13.0	38.2	48.7
BIG TURKEY LAKE SUB-BASIN			
BT1 - 9.0	52.7	32.9	14.4
BT2 - 4.5	63.5	26.1	10.4
BT2 - 5.0	4.4	19.8	75.8
BT3 - 3	27.4	55.3	17.3
BT3 - 6	16.7	53.2	30.1

TABLE 2: (cont'd)

SAMPLE NO.	GRAVEL (>2.0mm)	SAND	SILT & CLAY[2] (<0.075mm)
LOWER BATCHAWANA LAKE SUB-BASIN			
BT4 - 1.67	13.9	53.1	33.0
BT4 - 3.0	33.0	47.5	19.5
BT4 - 4.9	49.2	39.8	11.0
BT4 - 6.0	19.6	53.2	27.2
BT5 - 1.5	12.3	67.2	20.5
BT5 - 3.4	24.3	57.2	18.5
BT6 - 1.91	26.7	55.6	17.7
BT6 - 3.52	40.7	47.2	12.1
BT6 - 5.37	48.5	40.0	11.5
DISCHARGE STREAM SUB-BASIN			
DS - 0.68	30.0	40.6	29.4
DS - 1.52	63.9	30.0	6.1
DS - 1.93	59.2	32.6	8.2
RD - 1.65	20.1	62.2	17.7
RD - 2.49	38.3	44.1	17.6
RD - 5.5	39.4	52.7	7.9
RD - 5.0	53.2	32.3	14.5
UD - 0.50	13.7	59.0	27.3
UD - 1.52	75.2	20.3	4.5
UD - 2.45	63.5	28.4	8.1
UD - 2.45	57.0	34.7	8.3

1. Site-depth (m) eg. H0 - 0.62
2. May contain very fine sand

TABLE 3: AVERAGE RELATIVE ACID NEUTRALIZATION CAPACITY OF THE OVERBURDEN SAMPLES BY SUB-BASIN AND DEPTH

BY SUB-BASIN

Lower Batchawana Lake	X = 0.58%
Wishart Lake	X = 1.25%
Big Turkey Lake	X = 0.97%
Discharge Stream	X = 0.59%

BY DEPTH OF SAMPLE (ALL BASIN AVERAGE)

Sample Depth Interval

1 meter	X = 0.29% S = 0.17	N = 5
1 - 2 meters	X = 0.58% S = 0.31	N = 17
2 - 3 meters	X = 1.11% S = 0.67	N = 9
3 - 4 meters	X = 0.91% S = 0.42	N = 7
7 meters	X = 1.4% S = 1.95	N = 7

TABLE 4: X-RAY DIFFRACTION ANALYSIS OF SELECTED SAMPLES (<0.075 mm FRACTION)

SAMPLE NO.	CHLORITE	ILLITE	MONT-MORILLONITE	QUARTZ	FELDSPAR	AMPHIBOLE
HO-1.24	X	tr	ND	X	X	X
H1-3.70	X	tr	X	X	X	X
H2-1.68	X	ND	ND	X	X	X
RO-1.65	X	X	ND	X	X	X
RO-5.0	X	ND	ND	X	X	X
WO-0.74	X	ND	ND	X	X	X
WO-1.25	X	ND	X	X	X	X
WO-2.90	X	ND	ND	X	X	X
BT1-3.41	X	tr	X	X	X	X

X - present
ND - not detectable
tr - trace

TABLE 5: INORGANIC CARBON, ORGANIC CARBON AND SULPHUR ANALYSIS FOR SELECTED SAMPLES

SAMPLE NO.	SIZE FRACTION mm	INORGANIC CARBON %	ORGANIC CARBON %	SULPHUR %
HU0-0.68	2.00-0.425	0.17	0.28	<0.02
	0.425-0.250	0.10	0.22	"
	0.250-0.150	0.14	0.29	"
	0.150-0.075	0.12	0.43	"
	<0.075	0.26	0.82	"
HU1-1.8	2.00-0.425	0.04	0.08	"
	0.425-0.250	0.02	<0.02	"
	0.250-0.150	0.04	0.04	"
	0.150-0.075	0.02	0.02	"
	<0.075	0.06	0.16	"
H1-2.7	0.425-0.250	tr	<0.02	"
	0.250-0.150	tr	<0.02	"
	0.150-0.075	ND	0.02	"
	<0.075	tr	<0.02	"
H1-3.7	2.00-0.425	ND	0.04	"
	0.425-0.250	0.02	<0.02	"
	0.250-0.150	tr	<0.02	"
	0.150-0.075	0.04	0.02	"
W0-1.75	0.425-0.250	ND	0.04	<0.02
	0.250-0.150	ND	0.04	0.03
	0.150-0.075	0.06	0.02	<0.02
	<0.075	0.02	0.04	"
W0-4.0	0.425-0.250	0.02	<0.02	"
	0.250-0.150	ND	0.02	"
	0.150-0.075	0.02	0.02	"
	<0.075	ND	0.04	"
W0-7.0	0.425-0.250	ND	0.06	"
	0.250-0.150	0.08	0.02	"
	0.150-0.075	0.06	0.06	"
	<0.075	0.04	0.22	"
RD-1.65	0.250-0.150	ND	0.04	"
	0.150-0.075	ND	0.04	"

TABLE 5: (cont'd)

SAMPLE NO.	SIZE FRACTION/mm	INORGANIC CARBON %	ORGANIC CARBON %	SULPHUR %
RD-5.0	0.150-0.075	ND	0.04	"
	<0.075	0.04	0.04	"
BT6-3.5	<0.075	0.04	0.04	<0.02
BT2-3.37	0.250-0.150	ND	0.02	0.03
	0.150-0.075	0.02	<0.02	<0.02
	<0.075	0.04	0.02	"